

## ANALYSIS OF INCREASING OF CONCRETE COMPRESSION STRENGTH TO CONCRETE'S AGE DUE TO ADDING ADMIXTURE OF SIKAMENT-163

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### Abstract

*This research presents the study about the effects of adding admixture Sikament-163 to the increasing of concrete compression strength vs. concrete's age. The percentage of Sikament-163, which is added in concrete mixture, is 1.0 % by cement weight. This research was conducted using each 25 of test specimens for normal concrete and added Sikament-163 concrete with the same slump. The tests were conducted when the concrete's age reached 3, 7, 14, 21 and 28 days. The results of test show that the concrete compression strength of the concrete using Sikament-163 increase 13.5 % average above the normal concrete for each concrete's age. This is because the adding admixture Sikament-163 into concrete mixture can reduce the volume of used water for the same slump; therefore, concrete, which was produced, is more compact and more strength.*

**Keyword:** concrete, sikament-163, compression strength

### 1. Introduction

Concrete is made from a properly proportioned mixture of hydraulic cement, water, fine and coarse aggregates, and often, chemical or mineral admixtures. The most common hydraulic cement used in construction today is portland cement. The successful use of concrete in construction depends not only on knowing the right proportions of materials to use for a particular job, but also, knowing how to select the right materials. This requires knowledge of the properties of each of the materials and understanding the tests used to measure those properties.

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time or color. Some admixtures have been in use for a very long time, such as calcium chloride to provide a cold-weather setting concrete. Others are more recent and represent an area of expanding possibilities for increased performance. Not all admixtures are economical to employ on a particular project. Also, some characteristics of concrete, such as low absorption, can be achieved simply by consistently adhering to high quality concreting practices.

Admixtures vary widely in chemical composition, and many perform more than one

function. Two basic types of admixtures are available: chemical and mineral. All admixtures to be used in concrete construction should meet specifications; tests should be made to evaluate how the admixture will affect the properties of the concrete to be made with the specified job materials, under the anticipated ambient conditions, and by the anticipated construction procedures.

Water-reducing admixtures are groups of products that are added to concrete to achieve certain workability (slump) at a lower w/c than that of normal concrete. Water-reducing admixtures are used to improve the quality of concrete and to obtain specified strength at lower cement content. They also improve the properties of concrete containing marginal- or low-quality aggregates and help in placing concrete under difficult conditions (ACI Comm. 212 1963). Although using admixtures in concrete improves concrete's properties, misusing any kind of admixtures will negatively affect these properties. It is therefore important to follow the manufacturer's recommendations whenever admixtures are used. Sikament admixture; particularly Sikament-163 begins to be used people in construction in Palu; therefore, study about using of the admixtures in concrete mixture need to be conducted to evaluate it's effects to the concrete's characteristic such as

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concrete compression strength, workability of concrete, durability of concrete, etc.

## 2. Literature Review

The chemistry of concrete admixtures is a complex topic requiring in-depth knowledge and experience. A general understanding of the options available for concrete admixtures is necessary for acquiring the right product for the job, based on climatic conditions and job requirements. Based on their functions, admixtures can be classified into the five major categories; i.e. retarding admixtures, accelerating admixtures, super plasticizers, water reducing admixtures, and air-entraining admixtures.

### 2.1 Types of Admixture

- Retarding admixtures

Retarding admixtures slow down the hydration of cement, lengthening set time. Retarders are beneficially used in hot weather conditions in order to overcome accelerating effects of higher temperatures and large masses of concrete on concrete setting time. Because most retarders also act as water reducers, they are frequently called water-reducing retarders. As per chemical admixture classification by ASTM-ASTM C 494, type B is simply a retarding admixture, while type D is both retarding and water reducing, resulting in concrete with greater compressive strength because of the lower water-cement ratio.

Retarding admixtures consists of both organic and inorganic agents. Organic retardants include unrefined calcium, sodium,  $\text{NH}_4$ , salts of lignosulfonic acids, hydrocarboxylic acids, and carbohydrates. Inorganic retardants include oxides of lead and zinc, phosphates, magnesium salts, fluorates and borates. As an example of a retardant's effects on concrete properties, lignosulfate acids and hydroxylated carboxylic acids slow the initial setting time by at least an hour and no more than three hours when used at 65 to 100 degrees Fahrenheit.

- Accelerating admixtures

Accelerators shorten the setting time of concrete, allowing a cold-weather pour, early removal of forms, early surface finishing, and in some cases, early load application. Proper care must be taken while choosing the type and proportion of accelerators, as under most conditions, commonly used accelerators cause an increase in the drying shrinkage of concrete.

Calcium chloride is a common accelerator, used to accelerate the time of set and the rate of strength gain. It should meet the requirements of ASTM D 98. Excessive amounts of calcium chloride in concrete mix may result in rapid stiffening, increase in drying shrinkage and corrosion of reinforcement. In colder climates, calcium chloride should not be used as an anti-freeze. Large amount of calcium chloride is required to lower the freezing point of the concrete, which may ruin the concrete.

- Super plasticizers

Super plasticizers, also known as plasticizers, include water-reducing admixtures. Compared to what is commonly referred to as a "water reducer" or "mid-range water reducer", super plasticizers are "high-range water reducers". High range water reducers are admixtures that allow large water reduction or greater flow ability (as defined by the manufacturers, concrete suppliers and industry standards) without substantially slowing set time or increasing air entrainment.

Each type of super plasticizer has defined ranges for the required quantities of concrete mix ingredients, along with the corresponding effects. They can maintain a specific consistency and workability at a greatly reduced amount of water. Dosages needed vary by the particular concrete mix and type of super plasticizer used. They can also produce a high strength concrete. As with most types of admixtures, super plasticizers can affect other concrete properties as well. The specific effects, however, should be found from the manufacturer or concrete supplier.

- Water reducing admixtures

Water reducing admixtures require less water to make a concrete of equal slump, or increase the slump of concrete at the same water content. They can have the side effect of changing initial set time. Water reducers are mostly used for hot weather concrete placing and to aid pumping. A water-reducer plasticizer, however, is a hygroscopic powder, which can entrain air into the concrete mix via its effect on water's surface tension, thereby also, obtaining some of the benefits of air-entrainment.

- Air-entraining admixtures

Air-entraining agents entrain small air bubbles in the concrete. The major benefit of this is enhanced durability in freeze-thaw cycles, especially relevant in cold climates. While some strength loss typically accompanies increased air in

concrete, it generally can be overcome by reducing the water-cement ratio via improved workability (due to the air-entraining agent itself) or through the use of other appropriate admixtures. As always, admixtures should only be combined in a concrete mix by a competent professional because some of them can interact in undesirable ways.

Bonding admixtures, including addition of compounds and materials such as polyvinyl chlorides and acetates, acrylics and butadiene-styrene co-polymers, can be used to assist in bonding new / fresh concrete with old / set concrete.

## 2.2 Concrete Compression Strength

The properties of concrete depend on the quantities and qualities of its components. Because cement is the most active component of concrete and usually has the greatest unit cost, its selection and proper use are important in obtaining most economically the balance of properties desired for any particular concrete mixture.

The concrete compression strength will increase by increase of its age as the Figure 1 shown below. The increasing of concrete compression strength is affected by some factors such as water cement ratio, curing temperature, etc. The higher of its water cement ratio the lower of its increasing strength.

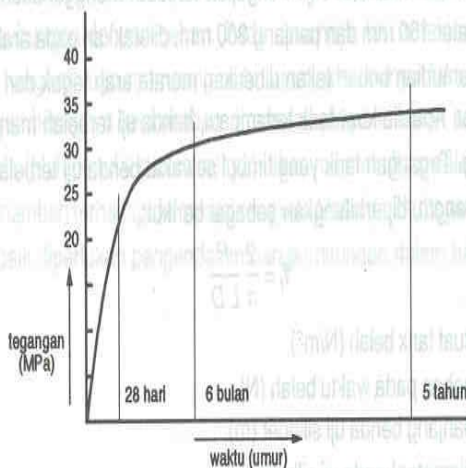


Figure 1. Relation between Concrete compression strength to concrete's age

Type I / II Portland cements, which can provide adequate levels of strength and durability, are the most popular cements used by concrete

producers. However, some applications require the use of other cements to provide higher levels of properties. The need for high-early strength cements in pavement repairs and the use of blended cements with aggregates susceptible to alkali-aggregate reactions are examples of such applications.

It is essential that highway engineers select the type of cement that will obtain the best performance from the concrete. This choice involves the correct knowledge of the relationship between cement and performance and, in particular, between type of cement and durability of concrete.

The manufacture and composition of Portland cements, hydration processes, and chemical and physical properties have been repeatedly studied and researched, with innumerable reports and papers written on all aspects of these properties.

- The Effect of Water / Cement Ratio to Concrete Compression Strength.

The strength of hardened cement depends on the number of water used for the hydration process takes places. The hydration process basically, needs water of about 25 % of cement weight (Tjokrodinulyo, 1996). Abrams' Law states that assuming full compaction, and at a given age and normal temperature, strength of concrete can be taken to be inversely proportional to the water/cement ratio as the formula below,

$$f'c = \frac{A}{B^{wcr}} \dots\dots\dots(1)$$

where,  $f'c$  and  $wcr$  are the concrete compression strength and water/cement ratio respectively; while  $A$  and  $B$  are constants. The higher the ratio, the greater the water consequently, the concrete assumes less compressive strength. Also, more days of wet curing are required to obtain the hardness necessary to hard off moisture migration. For example, the ideal ratio is 0.40 to 0.45, which would require seven days of wet cure. The number of water used in concrete mix is strongly related to the slump value of concrete fresh. The more water used in the concrete mix, the higher the slump.

The relationship between cement and water content is crucial importance to the concrete durability. Capillary porosity formed from residual spaces occupied by mix water increases with higher w/c ratio within ordinary Portland cement. In this manner, increased water content within the original

mix indicates a lower strength and a potential decrease in durability.

- *The effect of Admixtures to Concrete Compression Strength.*

The concept of using admixtures in concrete mixture can be seen in the Figure 2 below. As can be seen from the figure; the adding of admixture into concrete mixture at the same slump with normal concrete by reducing used water can increase the concrete compression strength. The concrete compression strength also can be increase by adding cement as the picture shows; however adding cement will reduce workability of concrete due to reduce of concrete slump. Even using cement exceed from the needed amount will generate a new problem in concrete itself, i.e. it will generate shrinkage and creep in concrete at earlier

time; therefore it will reduce concrete compression strength (Haidar, 2002).

### 3. Experimental Program

#### 3.1 Material Testing

The materials used to produce concrete in this research should be fulfilling the required specification before used; otherwise, the materials cannot be used. Those materials are both fine and coarse aggregates, cement and water. The coarse aggregate in from stone crushed was taken from Taipa river, while fine aggregate was taken from Palu river. The used cement selected from type I brand Tonasa.

The aggregates' testing, which are done; are sieve analysis, aggregates water content, aggregates soil content, specific bulk gravity, organic content and wearing out test by Los Angeles machine.

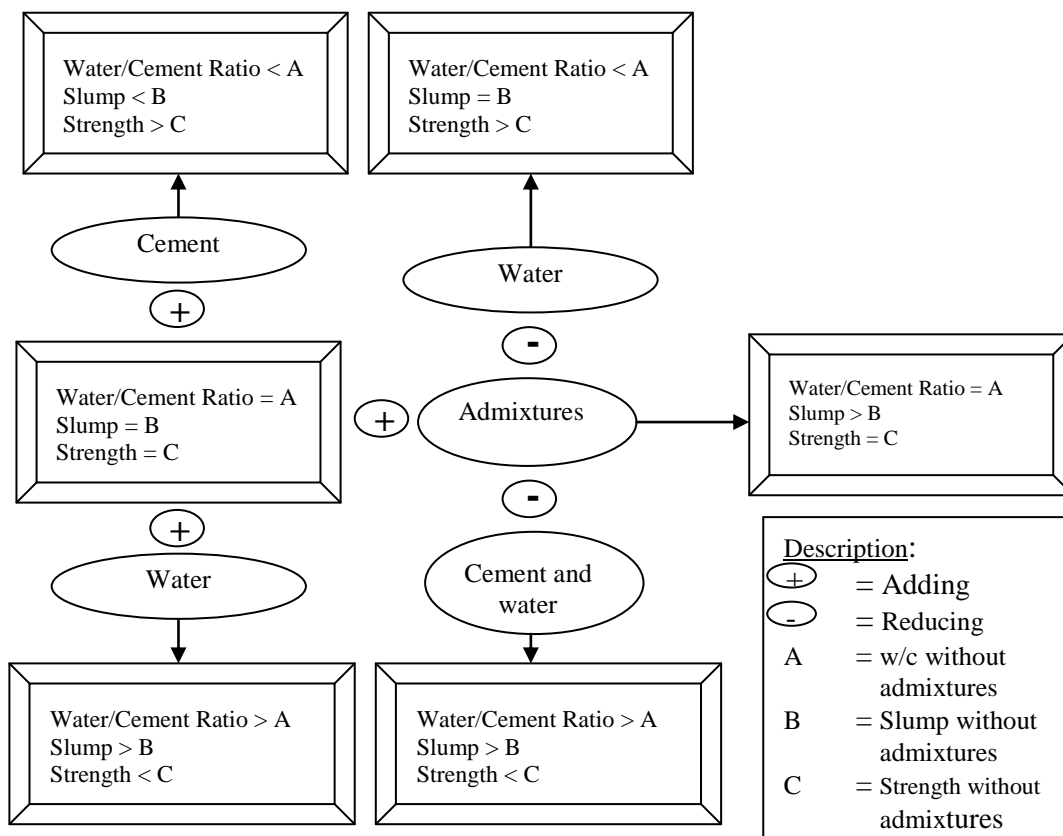


Figure 2. Concept of Using Admixtures

### 3.2 Mix design

The composition of materials, which used in the concrete mix, is calculated based on the Indonesia code for Normal Concrete Mix Design (SK SNI T-15-1990-03). The average of concrete compression strength is calculated by following equation.

$$f'_{cr} = f'_c + 1.64 S \quad \dots\dots\dots(2)$$

or  $f'_{cr} = f'_c + M \quad \dots\dots\dots(3)$

where,  $f'_{cr}$  = the average of concrete compression strength

$f'_c$  = required concrete compression strength.

$S$  = Standard deviation value (taken 7 MPa if the previous experienced

data not available).

$M$  = Additional value, Margin; It is taken 12 MPa if the previous data not available.

### 3.3 Sample test

The samples made of concrete cube of 150 mm x 150 mm x 150 mm size. Tests of the sample cubes were done when those ages were 3, 7, 14, 21 and 28 days. The number of samples used in the test can be seen in the Table 1.

## 4. The Experimental Results and Discussion.

### 4.1 The Experimental Results.

The concrete compression test results at each concrete's age is presented in the Figure 3.

Table 1. The number of samples used in the research

| Concrete type                                  | Concrete Age (days) |   |    |    |              | Total     |
|--|---------------------|---|----|----|--------------|-----------|
|  | 3                   | 7 | 14 | 21 | 28           |           |
| Number of Normal Concrete specimens            | 5                   | 5 | 5  | 5  | 5            | 25        |
| Number of Concrete specimens with Sikament-163 | 5                   | 5 | 5  | 5  | 5            | 25        |
|  |                     |   |    |    | <b>Total</b> | <b>50</b> |

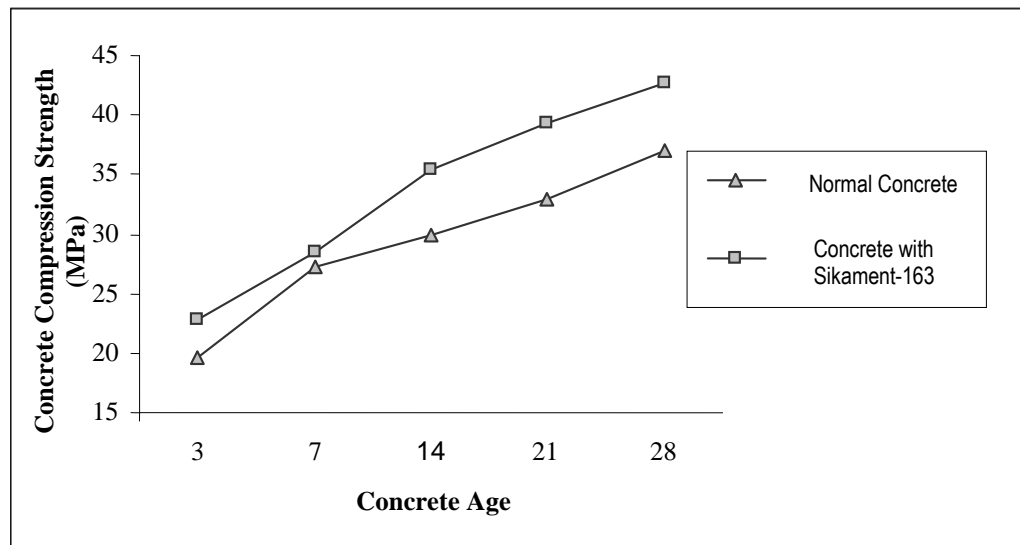


Figure 3. Graph relation between concrete compression strength to concrete's age

The test results show that the concrete compression strength of concrete with Sikament-163 are 13.5 % average above of compression strength of normal concrete. At the age of three days for example, the compression strength of concrete with Sikament-163 is 22.756 MPa, while the compression strength of normal concrete only achieve 19.574 MPa. Similar to the compression strength on the age of 28 days; the average compression strength of concrete with Sikament-163 is 42.756 MPa while the compression strength of normal concrete just achieve 36.932 MPa.

#### 4.2 Discussion

The above graph shows that the normal concrete compression strength on the 28 days age was achieved by concrete with Sikament-163 on the 14-day age. This show that the hydration process in concrete with Sikament-163 is faster than in normal concrete; therefore, the compression strength of concrete with Sikament-163 on each age of concrete always above than the compression strength of normal concrete as the Sikament-163 also works as super plasticizers.

As can be seen from the graph, the compression strength of concrete with Sikament-163 higher than the normal concrete's, which is both of them were designed to the similar slump and strength design. As the result, used water in the concrete with Sikament-163 is less about 25.32 % than used in the normal concrete. Therefore, concrete produced with Sikament-163 is more compact and stronger than normal concrete. Using the same amount of water will produce concrete with difference slump. The slump of concrete with Sikament-163 is higher than slump of normal concrete. It also means that the Sikament-163 admixture can improve concrete workability.

In conclusion, Sikament-163, which is produced by Sika Company, can be used for both as Water reducing admixtures and as Super plasticizers, which work properly to increase concrete compression strength and shorten the setting time of concrete.

#### 5. Suggestion for the future work

It is needed to study the effects of Sikament-163 admixture to the durability concrete and the maximum percentage of Sikament-163, which can be added into concrete mixture by adding different percentage of the Sikament-163 into concrete mixture.

#### 6. References

- Anonim , 2003, "*Bahan Presentasi Sika*", PT Sika Indonseia
- Callister Jr., W. D. 2003, *Materials Science and Engineering —An Introduction*, 6th ed. New York: Wiley,
- Departemen Pekerjaan Umum, *Tata Cara Pembuatan Rencana Campuran Beton Normal (SK SNI T-15-1990-03)*, Yayasan LPMB, Bandung.
- Gani, M.S.J., 1997, *Cement and Concrete*, Chapman and Hall
- James M. dan Harper, P.E., 1999, *Effects of Aggregates on Concrete Properties*, Journal of Materials Engineering, ASCE
- Khalil Haidar, 2002, *Influence of Porosity on Fracture Characteristics in Mortar Structures*, 15<sup>th</sup> ASCE Engineering Mechanics Conference.
- Mehta P.K. dan Paulo Monteiro J.M., 2001, *Concrete: Microstructure, Properties and Matrials*.
- Murdock, L.J. dan Brook, K.M. 1999, *Bahan dan Praktek Beton*, Erlangga. Jakarta.
- Neville, A.M. dan Brooks, J.J., 1998, *Concrete Technology*, Longman Singapore Publisher.
- Ran Huang and Chung Chia Yang, 2000, *Effects of Aggregate Volume Fraction on the Elastic Moduli and Void ratio of Cement Based Materials*, Journal of Marine science and Technology, Vol.8, No, 1.
- Raymond W.N. Chan dan Erich P.W Chan. 1999, *Using Admixtures for Concrete Construction*, Journal of Materials Engineering, ASCE.
- Supartono, F.X, 1999, *Rancangan Campuran Beton Mutu Tinggi Berdasarkan Rumusan Abrams-FXS*, Indoconstruction.
- Tjokrodinuljo, Kardiyono. 1996, *Teknologi Beton*, Jurusan Teknik Sipil Universitas Gadjah Mada. Yogyakarta.